LIVERPOOL

GEOLOGICAL ASSOCIATION.

JOURNAL.

VOLUME XIII.

SESSION 1892-93.

LIVERPOOL:
J. DONALD, PRINTER, 495, PRESCOT ROAD, OLD SWAN.

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The Authors only are responsible for the facts and opinions in their respective Papers.

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ABSTRACT OF THE PROCEEDINGS

OF THE

Liverpool Geological Association.

SESSION 1892-93.

ORDINARY MEETING,

Held in the Free Library, William Brown Street, on Monday, 7th November, 1892, the President, Mr. D. Clague, F.G.S., in the Chair.

A communication was read by Mr. T. R. Connell on a boring at Mickleham Manor, Gloucestershire.

Exhibits:—An unknown fossil plant from St. Helens was exhibited by the President, and a section of a concretionary nodule from the boulder clay at Bootle was exhibited by the Secretary.

The President then read his Annual Address.

PRESIDENT'S ADDRESS.

The opening meeting of a new Session is a fitting time to take a general survey of the present state of the particular branch of study in which we are engaged—to take a retrospect of the way we have come, the work we have done, and looking forward to anticipate future work—lay our plans, fix purposes, and arrange to give them effect.

It would not be strange if in the rapid march and brilliant developments in other branches of study ours were for the moment left slightly in the shade.

Astronomers are now jubilant with their new methods of research, and the fascinating results—new planets, sister worlds of our own, the existence of which was never suspected before—impress their portraiture on the sensitive plate of the teleo-camera. Jupiter, coming nearer to us than is his wont, whispers to the attentive ear of the astronomer of a fifth satellite, so small, and so near the primary that its existence was never before thought even possible. Mars, with lurid light, shows to careful observers with their splendid instruments his marvellous system of canals and polar ice caps, the one doubling as the other, turned to the sun, grows smaller, and again becoming single as the polar cap increases with winter severity—awakening in the minds of the thoughtful strange fancies respecting the remarkable phenomenon.

Agriculturists are rubbing their hands in glee, as they are awakening to the possibility of again making their pursuits profitable by somewhat altering their methods of work.

No wonder if amidst all that is new and novel, a science like ours, which, though a comparatively new one, has reached its maturity, and has buried some generations of earnest workers, should be for a moment forgotten by the general public, and that nominal geologists, whose knowledge of its fascinations is very scant, should think it a waning science. Earnest students have, however, nothing to fear. Those brilliant pronouncements I have referred to were not born in a day, are not the records of a moment's inspiration, but the result of long years of weary, patient, persevering work on the part of men whose patience never tired, and whose zeal never cooled. Those discoveries are not creations, but evolutions. Gradually the instruments of study were made more and more perfect, observers more acute, their

knowledge of accumulated discoveries in the past more perfect; so that when a tiny speck was seen on the plate it was instantly recognised as something not before known, its position in space calculated, and its orbit made known.

So the present may be the time of patient, constant plodding by the geologist, careful noting of every fact and incident that comes before him, whether he understands it or not—comparing notes with other observers—and all increasing their own and other students' stock of knowledge. Bye-and-bye these facts will throw light upon each other, and, like converging roads, meet at a common centre, where will be found hitherto unknown truths—new fields of observation and experiment will open out in such a way as to appear to casual onlookers as a kind of inspiration.

It appears to me that the position in which we are at present placed is that of travellers wearily, it may be, travelling along those converging roads—or engineers digging trenches in all directions, but constantly nearing the point of final attack.

Our Association was instituted in 1880 by the students in Mr. Semmons' Geology and Mineralogy Class for the purpose of keeping together and continuing their studies in the interesting pages of the "Great Stone Book." The name at first was the "Geological Students' Association," and membership was restricted to persons who had gone through a course of training in some class and held a Government certificate. It was soon seen, however, that this restriction was an unwise one, as there were many persons desirous of joining with us who were much interested in the subject, although they had not studied in our classes. Still it was, and is, a *Students'* Association—a fact which, I trust, will never be forgotten. It will be an evil day for us as individuals and as an Association when we cease to be *students*.

Whilst yet an infant Society, much help was rendered by gentlemen who, though not members with us, yet sympathised

with the new movement, and many joined us nominally as members to help us with their subscriptions and names who otherwise were in no sense likely to become active members. During that period of our existence there were not so many learned societies amongst us as at present, and we had a large accession of numbers. Our roll of membership was a comparatively lengthy one. Then came the time of reaction. I need not enter into any details of the causes which occasioned it, but the inevitable reaction came, when our numbers were reduced, our finances became embarrased, and there were serious thoughts indulged as to the propriety of winding up the affairs of the Association and terminating its existence. Happier thoughts, however, prevailed, and we have, I think, entered upon a new lease of life, which I hope will prove to be a grander phase of its existence, in which we shall do well to remember—learning lessons from the past—the courses and plans which have worked well and led to successful issue, and continue to work along those lines; and also to note those plans which result in disaster and loss, and avoid them. At the same time be constantly on the alert to adapt ourselves to the new and ever varying conditions in which we may be placed, not slavishly following the old plans because they are old, when new ones can be shown to be better; nor, on the other hand, giving up old plans in favour of new ones just because they are new.

One of the things to be remembered constantly is that ours is no longer an infant Society, to be nursed and fostered by sympathising friends from outside. Having won a position by means of some extraneous help, we must now maintain it by our own exertions and work. Not that I would for a moment advocate a haughty, stand-off policy, which would despise or decline friendly assistance from gentlemen not of our Society—that, I hope, we shall always welcome and receive—but we must not be dependent upon this outside help. We must learn to be a *self-help* Society, each member

studying what and how much he can do to make our work effective.

I said that this is the time for patient plodding—gathering together facts, and collating those facts. In this work each one can do something: this our past experience abundantly proves. (A number of examples were cited from the experiences of members showing that careful observation of Nature's work had removed difficulties which had been experienced when isolated facts and phenomena were looked at separately).

Now if for a moment I spoke as if in doubt about our present position, it is not that I think that geological studies are losing their hold on our members or on the thinking portion of the community. Never before did I know of so much real good work being done by the members of our Association. I know members are patiently pursuing definite courses of inquiry, quietly storing up facts, and seeking information about those facts; in good time these labours will, I doubt not, be made known to us in the shape of communications. All I intended to convey is that at present we do not present to the public eye anything very brilliant, but quiet, plodding work is being done; the pyrotechnic display will come in proper time, or I trust not at all.

Never did I have more hope of the spread of geological truth; never before had I so many geological students, all of whom I try to imbue with these thoughts: to learn all that other men have discovered, and go to Nature to learn fresh thoughts from her own teaching.

Such the advice I give to every member of the Geological Association, with this addition: when you have learned, whether from books or from Nature, anything new, come and tell us about it, that we may rejoice in your joy and share in your knowledge.

SUMMARY OF THE YEAR.

An excellent Address was issued in the first number of our Journal from the Council, drawn up by our late Secretary, indicating lines upon which the Association might work during the year—taking the four Committees as centres around which to gather. It is pleasing to note in the Annual Report—for which we are also indebted to Mr. Paterson—that he is able to say, in language terse and telling—"Reports from these Committees will be laid before you, giving a synopsis of work done by them during the year. There has been something attempted, something done." Your Council have already intimated their desire to work along similar lines this year, and depend upon the hearty co-operation of members to make the coming year more successful than the last one.

With regard to the Papers which have been read, I would like to remark that in the interesting Biological Paper by Mr. Hornell we had a course of study suggested which, if pursued, will lead to a better understanding of the problems of Palæontology—for it is by a study of the habits and associations of living creatures that we are able to understand the environments of the various bygone ages which constantly pass under review. We cannot too often be reminded that we read the past by studying the present.

Mr. Barber's Paper on "Pre-Historic Man" was an interesting communication, and valuable as drawing attention to that great borderland of Geology when the shadows of the past were rolling away, carrying with them the stories of the domination of fern, fish and lizard, and man steps on to the stage the hero of the future.

Two Papers on the Trias Rocks, by Messrs. E. Dickson, F.G.S., and H. C. Beasley, were worthy of notice, inasmuch as they extended our knowledge of the rocks upon which we live by giving us glimpses of them as seen in other counties. These two Papers were especially welcome as coming from gentlemen who are active workers in a sister society—Mr. Dickson being President and Mr. Beasley Secretary of the Liverpool Geological Society.

Mr. Williams did well to visit St. Erth during some of his happiest days, and when there devoting his impartial attention to the deposits at that place of the Crag age; and he did well to report to us the observations which he made.

In Mineralogy we had Mr. Semmons discourse to us in his own masterly manner on the "Environments of the Cornish Apatites," and trust we shall hear from him again.

In this subject we also had Mr. Roberts describing the "Microscopic Characters of Quartz." I hope Mr. Roberts will continue his work, and give us his experience with other minerals—he is well able to do so; and by patient continuance in so doing we shall have a useful repertoire of elementary microscopic petrology embodied in our Journal. Nor must the more advanced work done by Mr. Roberts and the Petrological Committee be overlooked. A detailed account of the past year's work has been added to the Library, ready for perusal by members who are specially interested in the subject. I hope we shall gradually have added to the MSS. carefully coloured drawings illustrating the subjects treated of.

From Mr. Wilding we had the practical issue of geology worked out in one of its branches—Terra-Cotta. In such an intensely practical age as the present, papers on the application of geology to arts and commerce must not be overlooked.

Is it not strange that Technical Education Committees do not realise the importance of the study of Geology, and are

unwilling to regard it as a technical subject, seeing that it is absolutely essential to a mastery of some important branches of trade. Perhaps we are a little to blame for this, in our unselfishness. We are not money grubbing enough. We have spent much of our time in studying the beautiful, the poetic, the grand, the abstruse parts of our subject, and have too much neglected the intensely practical part of it.

The quarryman, the collier, and the miner would be all the better for an acquaintance with the facts and theories of the geologist; but to the agriculturist and the architect the subject is equally important, and I take it that the signs of the time's intimate to us that we should devote more attention to the practical part of our subject than hitherto, and I commend it to our Council to be borne in mind in making their arrangements for the coming Session.

If I speak of the great importance of studying the practical application of geological knowledge to trade and commerce, it is not that I underrate the curious questions which now and again come to the front, if for nothing else than that they sharpen the faculty of observation and cultivate the reasoning power. Our thanks are therefore due to Mr. C. E. Miles for his clearly worked out Paper on the "Supposed Footprint Beds of Runcorn." I hope we shall hear more about it before long.

Whilst thus we devote much of our attention to our own work, it is wise to look abroad and see what our fellow workers are doing elsewhere. In the Geological Society Mr. T. M. Reade, F.G.S., has been discoursing on the rounding of sand grains as a possible means of identifying several beds of the Trias rocks—an interesting question, which I submit any of our members who possess microscopes would do well to work at. Mr. J. J. Fitzpatrick read a most interesting paper on the discovery of bones in the Deep Dale Cave, near Buxton.

I need scarcely say that the work of the premier Geological Society of the world has been of a most interesting character,

The late President—Sir A. Geikie, F.R.S., in his Anniversary Address on "Volcanic Action in Britain from the close of the Silurian to older Tertiary Times," is a sequel to his address of the preceding year. The two Addresses will be an excellent monograph on the ancient volcanoes of Britain.

On a former occasion I took the opportunity afforded me to note Sir A. Geikie's new division of the pre-Cambrian rocks into three:—1. *Archean*, which term he now applies to the crystallene rocks of the Isle of Lewis and those generally described by Murchison as the Fundamental Gneiss of Britain, in which are no trace of fossil. 2. *Dalratian*, which include the Torridon sandstone and the altered sedimentary rocks, quartites, and limestone, slates and schists of the Central Highlands. 3. *Uriconian*, which include masses which form the core of the ancient ridge which extends from near Wellington through the Wrekin, Caer Caradoc and other hills, until it sinks below the upper silurian, consisting partly of lavas, volcanic breccia, and rocks of the felsitic or ryolitic type. As these pass under the Olenellus zone—the oldest of the Cambrian rocks—he infers them to be pre-Cambrian, and accepts the name Uriconian for them.

Subsequently he referred to the Torridon sandstone, and recognising the difficulty in fixing its true place in the geological scale, has provisionally called it *Torridonian*—certainly pre-Cambrian, and certainly not Archean. In it traces of organic remains have been found.

And in speaking of the discovery of the Olenellus Zone as the lowest bed or zone in the Paradoxidian division of the Cambrian formation, he said he believed "we are only on the threshold of what was yet to be found."—*Journal of the L.G.S., vol. 48, part 2, p. 242.*

An interesting Paper by Professor Prestwich on "Raised Beaches" indicates that the work of quiet observation which

I have recommended to our members is the one practised by the leaders of our party.

Another Paper read at the London Society I must mention, that by Mr. Shone, of Chester, on the "Subterranean Erosion of Glacial Drifts," a probable cause of submerged peat and forest beds; which, briefly told, is when the clays cover sands the underground currents wash out the sands where there is sufficient outlet for them, with a consequent and inevitable lowering of the superincumbent beds. This is a most ingenious theory, based upon detailed observations, and is worthy the careful attention of geologists who reside, as we do, in a district where these operations may be studied.

This review of the history of our Association, the work done during the past year, and the general current of thought in the Geological world, indicate our work for the future.

ORDINARY MEETING,

Held in the Free Library, William Brown Street, on Monday, 5th December, 1892, the Vice-President, Mr. T. R. Connell, in the Chair.

NOMINATION.—Mr. T. R. Litton, F.G.S., Hon Sec. of the Geological Society of Australasia, was nominated by the Council as an Honorary Member.

Names of Members omitted from List, p.p. 2–4:—
Barr, W. B., 2, Barrington Road; Thomas, H., 15, Cheapside.

The following appointments were made by the Council:—

Petrological Committee.—D. Clague, C. F. Webb, R. W. B. Roberts and A. R. Pritchard.

Excursion Committee.—J. Brown, C. E. Miles & J. Paterson.

Little Ormeshead Committee.—T. R. Connell, R. Storey, D. Clague, C. F. Webb and G. A. Haworth.

Library.—J. Brown, D. Clague and T. R. Connell.

The following Paper was then read on

SOME OBSERVATIONS ON THE GEOLOGY OF WIRRAL.

BY OSMUND W. JEFFS.

1.—*Recent Deposits.*

For some miles the coast of Wirral is lined with hills of blown sand (dunes), the lower portions of which are consolidated and stratified. All the features of stratification, and current-bedding as seen in the solid rocks of the Trias, are reproduced in the sand-dunes. This has probably led to the opinion that some of our beds of Triassic sandstone may have had an æolian origin.

At Flaybrick Hill and some other places beds occur presenting well-rounded grains of sand, said to resemble the wind-blown sands of the desert. While it is possible that certain beds of the Trias may be remnants of subaerial (æolian) deposits, we must not allow the resemblance in structure of the stratified sand-dunes to carry us too far.

In the first place, the enormous area of the British Trias precludes the idea of these rocks being entirely of æolian origin, and, in the second place, we have to consider the difficulty of preserving such loosely-consolidated masses during the deposition of newer strata over them. If subsidence were now to take place, the sand-dunes of Cheshire would be all planed down and re-deposited by the sea; and it would be impossible to preserve their original structure. The rounding of the sand grains has not all been accomplished in a single period. Most of the grains have undergone a series of vicissitudes before being blown on the Cheshire shore. Each grain formed part of an older formation and was subjected to attrition more than once; indeed, if

it were possible for us to trace the history of one of these sand grains, we should be led back to some very early period of the Earth's geological history ere we could discover its parent source.

2.—*Post-Glacial Deposits.*

A fine series of these deposits is exposed on the Leasowe shore, the "Forest Bed" being the earliest geological feature in Wirral which received attention from any observer, for so long ago as 1796 an account of it appeared in the *Gentleman's Magazine.* Perhaps no other feature has been so much discussed in later times. There is a general agreement among various authorities as to the order of succession of the formations exposed on the shore, but all do not agree as to the significance of the "Forest Bed" itself. The position of the actual bed containing the pre-historic and historic antiquities so well described by the late Canon Hume, Mr. Ecroyd Smith, Mr. Charles Potter and others, has been definitely fixed by Mr. Potter, and there seems no doubt that these relics were derived from the "soil bed" or land surface, from which some of them are doubtless washed out and deposited on the underlying peat bed, where so many objects have been picked up.

The generally received theory of the "Forest Bed," or, more correctly speaking, "Peat Bed, containing stools and trunks of trees," is that the trees grew *in situ.*

On the other hand it has been held that the trees were brought down from another region and deposited in the situation where they are now found. Mr. Potter, who has devoted many years earnest study to the peat bed, and made several valuable observations connected with the post-glacial deposits (*e.g.*, the discovery of *Scrobicularia,* the bed of Bithynia sand and other observations recorded in the "Transactions" of the Historic Society of Lancashire and Cheshire, and elsewhere)

showed that the peat itself is formed of fresh water plants grown *in situ.* (Fresh water shells are embedded, though sparsely.) He, however, differentiates the questions of (*a*) origin of the peat and (*b*) origin of the arboreal growth, which on Lyellian principles are assumed to be contemporaneous.

Without entering fully into this controversy, I may mention that the late Mr. Mathieu Williams has described the effects of frequently recurring avalanches in some of the fiords and lakes of Norway by which large masses of timber-trees and foliage are brought down to the lower portions of valleys, and thence carried into lakes where they form a deposit of peat, somewhat suggesting the "forest beds" of our post-glacial series.

I do not think, however, that we can satisfactorily refer to any purely local cause of action in regard to the Leasowe beds, seeing that precisely similar formations occur at various localities round the coasts of Britain. These were evidently laid down during the same period, and indicate a succession of alternate marine and fresh water conditions and, probably, climatic changes. It is difficult to imagine a cause for the simultaneous drifting of trees over so wide an area, even supposing the whole country to have been covered with forests in the post-glacial period.

Mr. W. Shone, F.G.S., has recently (Q.J. Geol. Soc., vol. xlvii., 1892) adduced an ingenious theory to account for the subsidence of the forest bed, which he attributes to the action of subterranean water through the sands and gravels underlying the Boulder Clay. This effects a withdrawal of material, thus causing the overlying mass (frequently a peat bed) to fall in. This action is a *vera causa* of subsidence in many undoubted instances, as shown by the author, the importance of which has hitherto been probably under-estimated by geologists. The evidences at Leasowe, however, seem to

imply subsidence and re-elevation on a larger scale, and that other causes have aided "subterranean erosion."*

3.—Glacial Deposits.

Evidences of the great Ice Age are plentiful in Wirral. We have indications of the passage of glaciers in the striæ on rock surfaces which have been known for some years at Bidston, Flaybrick, Tranmere, and Hoylake, and those recently described by Mr. Beasley at Poulton; and the fine roche moutonnée at Flaybrick Hill. According to some observers, these striæ have been attributed to the agency of floating ice, and it is possible that we may have in Wirral instances of both kinds of striæ—those made by glaciers and (at another period) by stranded masses of ice. When we examine the deposits of boulder clay which fill many of the valleys and form the coast line on the banks of the Dee and Mersey, we are on firmer ground; for, notwithstanding some recently expressed statements of new school—or rather the revival of an old and hitherto discarded school—the evidences are, in my opinion, overwhelming in favor of the marine formation of the "Low Level Boulder Clay," containing the travelled erratics. The clays are to some extent stratified (the difference of the upper and lower portions as seen at Dawpool, for instance, being strongly marked), and intercalated with them are lenticular beds of stratified sand and pebbles, containing marine shells. These beds are often current bedded, faulted, and even ripple marked. Mr. T. Mellard Reade has remarked that the composition of the boulder clay depends largely on the character of the local rocks over which the clay is found. Thus, in Wirral the clay in colour and composition shows its local derivation, its mass being largely derived from the denudation of the Red Mail, which once spread over the greater portion of Cheshire.

*The late Robert Chambers ("Ice and Water") refers to a suggestion of Mr. John Cunningham (who, on boring through the Boulder Clay, found a quicksand), that "the subsidences in these cases is caused by the attack of the sea upon the sand beds of the Boulder Clay, sweeping it out and so causing the ground simply to collapse" (quoted by Canon Hume in "Ancient Meols.")

Numerous fragments of red marl rocks, ripple marked slabs, pseudomorphs of salt crystals, &c., occur in the boulder clay. These facts point to the conclusion that local subærial denudation was in progress at the time when the clay was deposited, and, as at the present day, rivers brought down their masses of sediment eroded from the land, which were then deposited over the sea bottom. Into this deposit the boulders were brought down by floating ice from other latitudes, and dropped into the clay as the ice gradually melted.

4.—*The Triassic System.*

(*a*) FAULTS AND SLICKENSIDES.—The Triassic rocks of Wirral are regularly bedded, generally having low angles of dip, and are not contorted or disturbed by plications. They are, however, much broken by faults. The walls of these faults are often beautifully slickensided. The groovings are usually oblique, and coincide roughly with the hade of the fault; but this is not always the case, for we have horizontal slickensides, and on breaking up the fault rock it frequently happens that a fragment exhibits striations in more than one direction on its several sides, thus indicating often very complex movements. At Thurstaston, slickensides with highly polished surfaces occur, standing out as thin veins of hard rock running through the sandstone. They resemble ferruginous bands, but when broken open exhibit a quartzose structure, and are seen to be true joint-planes, the walls of which cleave at the joint and fit closely together. The thickness of these joint-planes varies from $\frac{1}{8}$ to $\frac{3}{8}$ of an inch, some being almost as thin as a sheet of paper. Yet the walls are most beautifully striated, and these thin slickensides show a considerable amount of dislocation, or at any rate of lateral movement, which has not exemplified itself in actual faulting.

(*b*) LIFE OF THE TRIAS.—Mr. J. Hornell (see *Transactions, vol.* ix, *page* 74) has urged some good reasons for the retention

of the specific name of Cheirotherium for the hand-footed Labyrinthodon with whose footprints we are so familiar. To gain a fair idea of the life of the Trias we must go to the adjacent counties of Shropshire and Warwickshire, where, the rocks being more calcareous than in our neighbourhood, better conditions exist for the preservation of fossil remains. Even as it is, our knowledge of the fauna and flora of this period is small, but we must not therefore conclude that the period was one sparsely peopled with forms of life. The indications of footprints and other more problematical impressions in our neighbourhood are largely fragmentary, and frequently unsatisfactory as regards their determination. Many specimens of markings which cannot be identified with the impressions of specific animals may, however, safely be put down as indicative of the presence of animal life. In addition to the Cheirotherium, I have deciphered the footprints or impressions of at least four distinct species of smaller reptilia probably allied to the Rhyncosaurus, which have not as yet been accurately determined in any palæontological work.

(*c*) Stratigraphy.—The arrangement of the different beds of the Trias, and particularly the definition of a line separating the Keuper from the Bunter, has been a matter of some uncertainty. The earliest arrangement by Ormerod and others, which obtained prior to 1852, placed this separation at the base of the waterstones, all below this line being classed with the Bunter rocks. Afterwards Hull altered this classification and adopted the sub-divisions as given by the Survey, in which the line of separation was drawn at the base of the breccia and overlying white sandstones underneath the waterstones. Hull's classification has been again somewhat modified in the latest survey by Messrs. C. E. De Rance and Aubrey Strahan, the latter of whom has differentiated the Frodsham beds from the Lower Keuper building stones, and these again from the conglomerate basement beds of the Keuper. Even now some uncertainty exists as to what is and what is not the actual

base of the Keuper at certain points. Anyone comparing the last issued Survey Map of Wirral (1884) with the former maps (1850 to 1855) will see that much of the old nomenclature has been altered. In some cases, in my opinion, the alterations have not been carried far enough. Much of the original difficulty in separating the Keuper from the Bunter arose from the supposition that an unconformity existed between these two great sub-divisions. Now, I have not been able to recognise anywhere in the district any evidence of such unconformity beyond an *apparent* unconformity of dip, due to current bedding. There is, however, usually a line of erosion to be seen, though this is better seen in some sections out of the Hundred of Wirral, as at the Peckforton Hills.

The tri-partite division of the Bunter, though adopted by the Survey, seems to be faulty. The Upper Mottled Sandstone is usually considered to contain no pebbles. In the case of certain junction sections of the Keuper and Bunter in Wirral, to which I have elsewhere referred, the fact that an occasional pebble may have been found in the soft sandstone underlying the supposed base of the Keuper has been urged as evidence that the soft sandstone was *not* Upper Bunter. I have never been able to accept a determination which rests on this slender basis. In the sub-division known as the "Pebble Beds," a great thickness of rock occurs without pebbles (as seen in the Mersey Tunnel borings). Hence the title cannot be said to be distinctive, or always applicable. Recognising this, Mr. G. H. Morton, F.G.S., in the 2nd edition of his "Geology of the Country around Liverpool," has sub-divided the pebble beds into "upper" and "lower," the former containing few or no pebbles, the latter being described as "with numerous pebbles." There still exists, however, the difficulty of tracing any line of demarcation between the "Pebble Beds" and "Lower Mottled Sandstone" of the Survey; and as the title of "Pebble Beds" has ceased to have a distinctive value (since portions of the

beds do not contain pebbles at all), I consider that it would be better to discard a name which is so little characteristic.*

According to Mr. James Shipman, F.G.S., pebbles *do* occur in the Bunter immediately underlying the basement bed of the Keuper in the vicinity of Nottingham (see "The Geology of Stapleford and Sandiacre," *aut cit.*, p. 15). A section at Brookhill Road, in the vicinity of Stapleford, shows the base of the Lower Keuper resting on white coarse sandstone of the Bunter, containing a few pebbles. The Keuper in this vicinity appears, however, to rest on the Pebble Beds, and at a few spots (Stanton-by-Dale and Morley) mentioned by Mr. Shipman, rests directly on the Lower Mottled Sandstone. It should be remarked that the Keuper basement beds are there represented by "only a thin bed of grit," and the Cheshire beds known as the lower Keuper building stones, lying below the waterstones, do not appear to have any representatives in the neighbourhood of Nottingham.

The difficulties of recognising isolated examples of these beds of the Trias is often very great, and except where several of the beds are clearly seen in succession in one section, their determination is a matter of some doubt. Mistakes in nomenclature have been made both in Cheshire and Nottingham, and Keuper has been coloured in the maps as Buntor, and *vice versa.* The Pebble Beds of the Bunter often resemble Lower Keuper conglomerate, and the Upper Mottled and Lower Mottled sandstones have certain beds of very similar composition and appearance.

At Hilbre Island the upper strata appear to belong to the Lower Keuper, with conglomerate basement bed.† The sandstone is remarkably like that exposed at Hilbre Point, on the mainland of Wirral, which is marked "Keuper Basement Beds" on the Survey map. Mr. Morton, however, regards the beds at both these places as belonging to the "Pebble

* In the "Geology of Wirral" I have sub-divided the Bunter into two divisions only.

† See *Note on the Strata of Hilbre Island*, "Geology of Wirral," p.41.

Beds," though he describes certain physical characteristics of the beds at Hilbre Point as resembling the Keuper, and states that he has "not seen them before in the Bunter formation" ("Geology of Liverpool," 2nd edition, p. 94.)

5.—Coal Measures.

Some degree of interest has lately been excited in the problem of the extension of coal under Wirral by the commencement, some little time ago, of boring operations on Bidston Moss. From the scanty information which has been permitted to transpire respecting the operations at Bidston (the Engineer, Mr. Frederick W. Jones, being extremely reticent on the subject), it does not appear that the Coal Measures have yet been reached, the boring having only extended to a depth of about 1,000 feet. Though the actual thickness of the Trias at this point is unproved, it is probable that a depth of from 2,000 to 3,000 feet will have to be penetrated before reaching productive coal measures. At any rate, whatever may be its commercial success, the experiment will, from a geological point of view, be of the highest interest.

ORDINARY MEETING,

Held at the Free Library, William Brown Street, on Monday, 2nd January, 1893. The President, Mr. D. Clague, F.G.S., in the Chair.

ELECTION.—Mr. T. R. Litton, F.G.S., was elected an Honorary Member.

At the close of the ordinary business, the ordinary routine of reading a Paper was dispensed with, and the evening was spent in examining and discussing a large and varied collection of specimens of geological interest.

Amongst the exhibits was a choice collection of photographs illustrating the structure of the rocks and the effects of various forces of denudation. Valuable collections of fossil fish were shown by Messrs. H. Jones and C. Potter— the former showing some from the Old Red Sandstone of North Scotland, the latter cretaceous fishes from the south of England; some of the latter collection were specially interesting as containing specimens which had been examined and described by the late Sir H. Owen, K.C.B., &c., and which still bear his descriptive remarks.

Mr. W. S. Walker exhibited a collection of rock and mineral specimens illustrative of the close relationship which exists between the studies of Geology and Agriculture. The President showed geological maps and clinometers made by the students of his classes, also a unique collection of fossil teeth of different animals from the various formations. Trays of mineral crystals, all beautiful and some rare, were shown by Mrs. E. Clague. Mr. T. R. Connell exhibited his choice collection of Crocedolites, shells collected from the boulder clay by Mr. R. Thompson, and recent finds of animal remains from Leasowe Forest beds were shown by Mr. W. B. Barr. The large collection of Geological maps belonging to the Association and some of the rare and valuable books from the Library were spread on the tables for inspection by the members.

The Petrological Committee also exhibited their last year's work, along with typical rock sections for comparison.

After a somewhat lengthy examination of the exhibits, the Meeting was called to order by the President, when the various exhibits were freely discussed and suggestions made for the more efficient working of the Association.

ORDINARY MEETING,

Held in the Free Library, William Brown Street, on Monday, 6th February, 1893, the President, Mr. D. Clague, F.G.S., in the Chair.

Exhibits.—Mr. C. Potter exhibited fossil teeth of the ray, horns of red deer, breastbone of bos primogenius, vertebræ of whale, and tusk of boar.

A Paper was read on

"EOZOON,"

By Dr. Cecil F. Webb,

of which the following is an abstract.

The study of the Eozoon is certainly one of absorbing interest, as the origin of life on the earth is probably the most important of the unsolved problems that still perplex the record of its early history. The answer to the enigma remains shrouded in a fog, and as yet we possess no guide through its gloom, and no scientific light strong enough to dispel its mists and remove this fascinating field of enquiry from the hazy lands of speculation to the ever widening regions of determined fact.

Physicists have advanced their guesses to the existence of some life-bearing meteorite; chemists have striven to crown their long course of successful achievement in the manufacture of organic products by the creation of life itself; geologists have hoped, by the study of its earliest forms, to discover the lines along which biological research must proceed; and materialists have published their theories to answer their great sphinx riddle. But the problem has resisted alike the dreams and theories of philosophers and the retorts and microscopes of scientists.

The geological assistance rendered in the quest has been but trivial. The palæontological record—imperfect at the best—after affording a constantly lowering grade of organization with the increasing age of the deposits examined, snapped at the base of the Cambrian system, leaving as the oldest known fossils those so comparatively complex as brachiopods and crustaceans. Below lay huge masses of metamorphosed and igneous rocks some five or six miles in thickness, and in these apparently the story of the dawn of life on the planet had been obliterated beyond hope of recovery. But scientists do not readily despair; and as, by more diligent hammering, the list of fossiliferous schistose and metamorphic rocks in other parts of the globe have gradually increased, American geologists plucked up courage and expressed the confident hope that some traces of life might be exhumed. Hence it was that the announcement of the discovery of a fossil in the Lower Lawrentian rocks of Canada—vouched for by such men as Carpenter, Logan, Hunt, and Sir William Dawson—roused no ordinary excitement in the geological world, and was received as an earnest of much still to be unearthed; and when it was further stated that it was a foraminifer, it agreed so perfectly with current theories as to what the oldest fossil ought to have been, that it is little wonder that geologists accepted it with practical unanimity.

A most serious blow was struck in 1879 by Professor Moebius, the great authority on the Rhizopoda. He had been struck by the resemblance of Eozoon to a new genus of foraminifera which he had found in 1874 on the coral reefs of Mauritius, and had named *Carpentaria rhaphidodendron;* impressed with the value of his discovery, as elucidating and confirming the organic nature of Eozoon, he resolved to fling himself into the discussion, re-examine the whole of the evidence, and then, by the aid of his new genus, to demolish all opposition and establish for ever the "animalitäl" of Eozoon. He announced his intention, and invited geologists to

send him specimens. Eozoonists promptly complied with his request, and materials from all parts poured in upon him. Credner, of Leipzig; Hochsteller, of Vienna; Du Bois Raymond, of Berlin; and Dawson, of Montreal, all forwarded him their specimens. Eozoon Bavaricum he received from Fritsch, and Gumbels collection from Sadebcck; Leydig, of Bonn, sent those from the cabinet of Max Schultze; whilst Carpenter entrusted him with a large number of his choicest specimens, some of which he had never before allowed to leave his possession. From these, Eozoonists expected that Moebius would adduce an array of facts and arguments that would place their theory beyond dispute; and correspondingly bitter was their disappointment when they learned that as he examined the vast series of the most typical forms placed at his disposal he gradually lost faith, and finally lapsed into the ranks of their opponents. It was the story of Balaam over again; he had set out on his journey to curse, but he had blessed—and blessed with a weight of authority and power which no other man possessed. From that hour Eozoonism seemed doomed.

But it is time to turn from the controversy to Eozoon itself; before doing so, however, it is necessary to make two digressions—first, to examine the stratigraphical relations of the rock in which it occurs; and secondly, to examine the shell structure of the foraminifera in order to recognise the morphological relationship supposed to exist between them.

The Laurentian rocks, largely developed in North America —typically in Canada—are a vast series of metamorphic rocks divided into two groups. The lower, some 20,000 feet in thick ness, is composed entirely of metamorphic rocks—mainly gneiss and mica shist—interstratified with which are great beds of quartz and crystalline limestone, one of which is as much as 1,500 feet thick. Distributed through it are conglomerates and beds of magnetic and specular iron ore, and veins and beds of

graphite, which Dawson estimates would equal in quantity the coal seams of an equal area of the carboniferous rocks. The upper series of some 10,000 feet of stratified crystalline rocks, mainly gneisses and felspathic rocks, characterised by the abundance of labradorite, lies conformably upon it. It is in the lower series that Eozoon occurs. The first locality from which it was recorded was Burgess, in Ontario; but as many of the best specimens have come from the Grenville band of limestone at Côte St. Pierre, it will be better to describe that. Eozoon occurs there, as a serpentinized band in a massive limestone, interstratified between a layer of gneiss above and a thick bed of diorite and gneiss below. Many structures in these rocks Canadian geologists considered had long given presumptive evidence in favour of the existence of Laurentian life. They pointed to the vast beds of graphite (probably introduced as liquid hydrocarbons) as representing the last stage—that beyond anthracite—in the metamorphism of vegetable remains; they contended that the calcite had been deposited by some organic agency like the limestone beds of later date, and that the iron ores were due to the reducing action of plants similar to that of the gaillonella ferruginea of the Swedish lakes.

The shell structure of the forminifera need not detain us long, as a mere recapitulation of its terminology will suffice. The foraminifera, as everybody knows, consists of simple masses of protoplasm, in which is immersed a shell usually penetrated by a series of perforations, through which are protruded extensions of the protoplasm termed "pseudopodia." The shells are either chitinous, arenaceous (*i.e.*, composed of grains of sand or such like bound together by chitinous secretion), vitrious, or calcareous. Their structure is generally very simple, as in the lowest form it has but a single perforated cell wall, termed the "proper wall;" in compound shells the septum, or proper wall, is usually single, so that which forms the anterior wall of one chamber serves as the posterior wall of the next.

In more complex forms each chamber has its own proper wall, so that in these each septum, or "septal plane," consists of two lamellas. In still more complex forms these two proper walls are separated, and between them is developed "the intermediate" or "supplemental skeleton," through which, if largely developed, ramifies a series of canals containing prolongations of the sarcode, serving to preserve the vitality of the skeleton. Between these "body chambers" a further connection is established by "stolon passages" or bands of protoplasm. Thus, in one of the highest members of this order we should notice the "tubulated body" or "proper wall," the "intermediate skeleton," and the "body chambers" connected by "canal systems" and "stolon passages."

The objection that even if Eozoon or any other organism had lived in Laurentian time its relics could never haver survived the metamorphism which the rocks have since undergone, Gumbel answered by denying that the rocks had been metamorphosed, declaring they are now in their original condition; while Dawson says, "I call this prejudice," and proceeds to demolish it by referring to what he considers an analagous case of casts of coral by calcite and silicates, and of the body chambers of forminifera by glauconite, the latter of which are so well known as fossils from the greensand; and in recent seas, as in the Gulf Stream and Ægean, Dawson maintains that such would be obliterated by nothing short of the actual fusion of the rock. And he adduces Sterry Hunt's opinion that the association of serpentine with Eozoon is exactly on a par with these cases, and that as glauconite is hydrous silicate of iron and potash, and serpentine a hydrous silicate of magnesia, if we assume that in the Laurentian ocean magnesia played the *rôle* of iron and potash in recents seas, we can understand how the Laurentian serpentine was deposited under conditions similar to those of modern greensand.

The case against the proper wall seems far more conclusive. In the first place, the researches of both King and Rowney

and of Moebius make it clear that it is not truly analogous to the proper wall of foraminifera, as this fibrous layer is supposed to be a series of casts of the pseudopodial tubuli through the chamber walls; but in many specimens the fibres are placed in actual juxtaposition, whereas in foraminifera they are always isolated tubes scattered through the body wall. Their shape, as well as their arrangement, militates no less decisively against their foraminiferal nature; in foraminifera they are cylindrical tubes, but in Eozoon are prismatic needles or plates. In foraminifera, without exception, they go to the surface by the shortest possible route, and only curve or emerge at an angle when by so doing they can shorten their length. In Eozoon no such arrangement occurs; they branch off tangentially or obliquely, and may run for considerable distances in the chamber's walls. Moebius figures a specimen in which this disregard for a rule absolute among foraminifera is admirably seen. King and Rowney maintain that this so-called proper wall is but a layer of fibrous chrysotile, due to the alteration of the serpentine, and have pointed out several cases, two of which are figured, where a gradual passage can be traced from unaltered serpentine through various incipient stages till thoroughly fibrous—frequently where fissures in the serpentine cross the chamber casts. The walls of the serpentine along the crack are altered to exactly the same fibrous layer as the proper wall. "It is unnecessary," they say, "to add another sentence by way of argument in opposition to the view which ascribes the asbestiform layer to pseudopodial tubulation."

So now we must glance briefly at that so-called "protean" mineral – Serpentine. Serpentine is a hydrous silicate of magnesia, generally colloidal, the only crystals known being probably pseudomorphs; it varies extremely, and contains an extensive series of varieties and allomorphic modifications. Thus it is massive in common and noble serpentine, retinallite porcellophite, &c.; lamellar in antigorite, williamsite, marmolite,

thermophyllite, &c.; fibrous in chrysotile, picrolite, metaxite, baltimorite; flocculent in flocculite; scaly aggregates in bowenite. These forms are all essentially of approximately the same chemical composition, differing in the percentage of water and other details, and all graduate into one another, the whole series being truly allomorphic, *i.e.*, being of different forms, but of the same composition. To these many other hydrous silicates are closely allied—such as pyrosclerite, bastite, loganite, and chomerite. It is always as a modification of, or in association with, this group of minerals, inter-lamellated with calcite, or sometimes by a dolomite produced by the partial replacement of the calcite by carbonite of magnesia, that Eozoon occurs. All the various structures supposed to affirm its organic origin are but members of this series of minerals. The proper wall is but a layer of fibrous chrysotile, indistinguishable from that round the nodules described by Dellesse, in the ophite of Zeltes, in the Vosges, while gradual passages from this to amorphous serpentine are frequently observable as already discussed. The sarcode chambers consist of serpentine granules—"serpentin korper," as Moebius calls them; the intermediate skeleton is the calcite or dolomitic matrix, the stolon passages are simply crystals of pyrosclerite, and the canals are often metaxite. The points have been practically admitted by even Dr. Carpenter, who was forced into the admission that the case for the organic nature of Eozoon rested on the "assembly of facts which can only be separately paralleled elsewhere." To obtain such a structure all we require would be a bed of "lamellated ophite," or thin alternations or serpentine and calcite produced by the action of water charged with carbonate of lime on an olivine rock, and from this by heated water or other metamorphic agency. The edges of the serpentine grains would be altered to chrysotile, and crystals of pyrosclerite and metaxite would branch through the calcite, which at the same time would be partly dolomitised, and then a form mineralogically identical with Eozoon would ensue.

We have briefly stated the argument against the theory that Eozoon is organic, but we must not abandon it yet. Facts are fact, and the theory has many weighty arguments in its support.

ORDINARY MEETING,

Held in the Free Library, William Brown Street, on Monday, 6th March, 1893, Mr. W. H. Miles in the Chair.

A Paper was read:

"TWO DAYS ON THE GAULT AND GREENSAND,"

By Mr. W. L. Atkinson."

(Abstract.)

The Gault and Greensand are the lowest members of the upper cretaceous formation, and are found between the chloritic marl and the Folkestone beds. The Gault is a widely spread and varied deposit. In England the best exposure of it is at Folkestone, where it consists of about 100 feet of sands, clay and marl. The Greensand which is seen at the same place is a sandy deposit much thinner, and tinged a greenish colour by the presence of glauconite (silicate of iron). These beds extend from Devonshire into Yorkshire and Norfolk; are seen in the Isle of Wight, and passing under the English Channel reappear in Belgium, Germany and France. Their composition, as might be expected, varies according to the character of the rocks washed by the waves of the sea in which they were deposited—Jurassic, Neocomian, porphyries and granites.

I made my first acquaintance with the Gault at Hunstanton, a small watering place overlooking the shallow waters of the

Wash. The cliffs here form one of the most attractive geological sections on the coast, and consist of the Carstone, red and white chalks lying horizontally above each other, and extending the length of the cliffs. At the highest part the cliffs attain an altitude of 60 feet. The Carstone forming the base of the cliffs is of a ferruginous sandy character, containing many small pebbles and the fossils *Perna Mulletii* and *Ammonites Deshayesii*. The Carstone is considered to be the equivalent of the Folkestone beds. The red chalk which succeeds the carstone is of a bright red colour, and about four feet thick. The colour is due to peroxide of iron. Fossils are numerous, and the following may be enumerated, good specimens of some being easily procured:—*Belemnites minimus*, *Spongia paradoxica*, *Terebratula biplicata*, and *Ammonites auritus* — *Terebratula capillata* and *Bourguetiocrinus rugosus* being peculiar to the deposit.

A boring made at Holkham, a few miles to the east of the town, passed through eight feet of red chalk resting upon ten feet of blue gault, whilst eight or nine miles to the south of Hunstanton the red chalk is met with, and a little further to the south a red clay is found underlying the white chalk, as the red chalk does at Hunstanton; and further south still the gault clay is found taking the place of the red clay, thus indicating that the red chalk is of the same age as the gault.

My next visit to the Gault and Greensand was made at Folkestone. On the coast near to this place good sections can be seen of the Chalk, Chalk marl, Greensand, Gault, Folkestone and Sandgate beds. The Gault and Greensand are best seen at Copt Point and Eastwear Bay, to the east of the town. The gault is here divided into upper, lower, and junction beds, and these again into eleven zones distinguished by some particular fossil peculiar to them—generally some species of ammonite. Upon going to examine the beds I found that, owing to the quantity of rain that had just fallen having brought down masses of clay and sand on to the beach, and the water from the

springs above the clay running down the face of the cliff, it was impossible to study stratigraphical geology. I turned my attention to the fossils; these were abundant, and I soon gathered specimens of *Belemnites attenuatis*, *B. mucronata*, *Ammonites splendens* (with its colours bright and beautiful); but the best specimens were too fragile to be carried away—*Am. tuberculatus*, *Am. lautus*, *Inoceramus concentricus*, *I. sulcatus*, *Nucula pectinata*, *Rostellaria carinata*, and numerous fragments of hamites, also specimens of hematite and iron pyrites. Visiting this section again when its condition had improved, I was fortunate in meeting with Mr. J. Griffiths, who kindly pointed out the salient features of the locality. The section consists of stiff blue clays, marls, seams of greensand and phosphatic nodules. The following arrangement of the eleven zones and their distinguishing fossils, commencing at the lowest, is by Mr. T. G. Price:—*Am. interruptus*, *Am. auritus*, *Crustacea*, *Am. Delaruei*, *Am. lautus*, *Am. denarius*, *Am. auritus*, *Am. cristatus*, *Am. varicosus*, *Kingena lima*, *Am. rostratus*.

Coming after the sandy Folkestone beds, the clays and marls of the gault would lead to the conclusion that they were deposited in a gradually deepening sea, which was probably open to the south, as beds of greensand age are found in the South of France. Possibly the greensand proper may represent a period of rest or elevation, but the sinking certainly continued after its deposition, as is evidenced by the chalk lying thickly over both Gault and Greensand. This sinking would probably submerge much land that lay to the North during the gault period, as boulders of coal and igneous rocks are found in the chalk, which I am not aware of having been met with in the rocks under consideration.

ORDINARY MEETING,

Held in the Free Library, William Brown Street, on Monday, 1st May, 1893, the President, Mr. D. Clague, F.G.S., in the Chair.

Nominations.—Messrs. A. G. Kent Johnson, F.R.G.S., J. B. Dean, F.R.H.S., Lionel J. Jones, W. R. Fitzgerald Moore, C.E.,M.E. (Chilian Consul), Frank George Duff, M.E., H. Reynolds, F.R.G.S., F. J. Spence—all of Melbourne; Mr. Uriah Dudley, M.I.M.E., Silvertown, N.S.W.; and Mr. Frederick Johnson, M.E., of Wadnaninga, South Australia, were nominated for membership.

Exhibits.—Mr. R. Thompson exhibited a sketch of a large boulder recently exposed at Stanley brickfields, also bones of dog from the boulder clay there.

A Paper was read by the Secretary, Mr. A. R. Pritchard, on "The Mountain Limestone of North Wales," in which he dealt particularly with the outcrops at Llangollen and Newmarket. Mr. Pritchard exhibited a large number of fossil corals, brachiopods, &c., in illustration of his Paper.

A Field Meeting was held at Newmarket on 22nd May, 1893, conducted by the Secretary, Mr. A. R. Pritchard, when he pointed out and explained many of the features to which he referred in his Paper of May 1st. The private collections of many members are enriched with fossils collected on this occasion.

ORDINARY MEETING,

Held in the Free Library, William Brown Street, on Monday, 5th June, 1893, the President, Mr. D. Clague, F.G.S., in the Chair.

Elections.—Messrs. A. G. Kent Johnson, F.R.G.S., J. B. Dean, F.R.H.S., L. H. Jones, W. R. Fitzgerald Moore, C.E.,M.E., F. G. Duff, M.E., H. Reynolds, F.R.G.S., Uriah Dudley, M.I.M.E., F. Johnson, M.E., and F. J. Spence were elected members of the Association.

Nominations.—Mr. H. T. White, 1, Allerton Grove, Tranmere, and Miss S. Gluck, 52, Fairclough Lane, were nominated for membership.

Exhibits.—Mr. Joseph Brown exhibited several specimens of greenstone from Keswick, containing well developed crystals of garnet; also slabs of shale covered with graptolites.

A Paper was read by the President on "The Flora of the Coal Measures," which dealt specially with the ferns, and was illustrated with drawings and specimens.

A Field Meeting was held at Thatto Heath on 1st July, 1893, conducted by the President, who conducted the party from St. Helens to Thatto Heath Station, thence across the common, visiting various quarries on the way, and noting outcrops of coal generally illustrating the methods of geological mapping.

ORDINARY MEETING,

Held in the Free Library, on Monday, July 3rd, 1893, the President, Mr. D. Clague, F.G.S., in the Chair.

ELECTIONS.—Mr. H. T. White and Miss S. Gluck were elected members.

NOMINATION.—Mr. A. G. Jenks, 40, Brunswick Road, was nominated for membership.

A Paper was read on

THE INFLUENCE OF LOCAL GEOLOGY ON THE COMMERCIAL IMPORTANCE OF LIVERPOOL.

BY J. HERBERT JONES.

WHEN we come to trace out the rise and progress of our great centres of wealth and population we almost invariably find that they had their beginnings in the possession of some advantage given to them by Nature, either of mineral wealth, soil, climate or position. The richness and prosperity of the different States of Europe are largely due to their varied and valuable mineral deposits and to the suitability of the soil and climate—in some parts to the growth of corn, in others to the production of timber, and in most of the Southern portions of the Continent to the cultivation of the grape vine. Variety and peculiarity of geological formations have given great diversity to the scenery, while to the same cause are due many modifications of climate, and these combine to make some parts of Europe the most picturesque and delightful spots on earth to those in search of health or pleasure.

The rapid growth of America, its constant advancement in wealth, and its present position in the commercial world are chiefly due to those peculiarities of soil and climate which are favourable to the growth of cotton, corn and meat. To similar features is due the wealth of China in her production of tea; that of India in rice, &c.; and of Africa in the produce of her luxuriant forests of palm trees. The mineral riches also of this latter country have given considerable impetus to its growth and prosperity; and the like may be said of Australia and New Zealand, countries also peculiarly adapted for grazing purposes, the growth of wool and meat being now their chief sources of wealth.

Coming to our own country, can we not say that to its varied geological formations, ranging in almost unbroken sequence from the earliest known rocks to those which have been formed as it were but yesterday, does it owe its comparatively vast mineral wealth, diversity of soil, its rivers, ports and harbours, the beauty and variety of its coast and inland scenery—all of which have contributed towards placing it in the proud position to which it has attained, and which it maintains amongst the commercial nations of the earth?

Britain first became commercially important on account of her mineral possessions, tin having been sought for and exported from her coasts by the Phœnicians long before the Christian era. Each succeeding discovery of her natural resources has been marked by a progression, and if we compare a geological map with that showing the distribution of population it will be seen that the greater mass of the people are centralized in the vicinity of our chief minerals—coal and iron, and that here the greatest amount of wealth is to be found. It does not follow, however, that all the persons assembled in a mining district are directly concerned in mining industries. Facilities beget trade, and just as in the times before the advent of steam most manufactories were to be found on the banks of streams or rivers where water power could be had, so now they are chiefly assembled near to where fuel can be conveniently obtained for the production of the new power.

A large portion of the commerce of this country arises from the soil, the fertility of which and its adaptability to the cultivation of a large variety of produce are almost wholly due to the geological formations from which it has been derived, and upon which it in most cases rests. Glancing over these formations on the map, the granite, owing to its elevation and rugged character, is little cultivated, only some scanty sheep farming being carried on; it will be seen, however, that this rock occupies but very small and isolated districts. The trap rocks, which are similarly coloured,

MAP OF
ENGLAND & WALES.
SHOWING THE NUMBER OF PERSONS
TO AN ACRE IN EACH COUNTY
REFERENCE.
A. Agricultural.
C. Coal.
Com. Commercial.
I. Iron.
M. Manufacturing.
S. Salt.
SCOTLAND
NORTHUMBERLAND
A. Com.
CUMBERLAND
3/16
A
DURHAM
C
WESTMORELAND
North Riding
1/4
A
YORKSHIRE
1/2 Com
East Riding
C. M.
West Riding
ISLE OF MAN
3 1/4
C. I. M.
Com.

NORFOLK
LEICESTER SHIRE
RUTLAND
MONTGOMERY SHIRE
SHROPSHIRE
STAF
CAMBRIDGE SHIRE
HUNTINGDON SHIRE
NORTHAMPTON SHIRE
12.C.I.M
WARWICK SHIRE
SUFFOLK
CARDIGANSHIRE
RADNORSH
WORCESTER SHIRE
1.A.S
HEREFORD SHIRE
BEDFORD SHIRE
PEMBROKE SHIRE
CAERMARTHEN SHIRE
BRECKNOCK SHIRE
GLOUCESTER SHIRE
OXFORD
BUCKINGHAMSHIRE
HERTFORD SHIRE
ESSEX
MONMOUTH SHIRE
GLAMORGAN SHIRE
C.I.COM
BERKSHIRE
MIDDLESEX
4.COM
WILT SHIRE
SURREY
1 1/5.COM
KENT
SOMERSET SHIRE
HAMP SHIRE
A.COM
SUSSEX
DEVON SHIRE
DORSET SHIRE
I OF WIGHT
CORNWALL
Scale 50 Miles to 1 inch
50 40 30 20 10 0 50 100
J.H. Jones, Oct 30.1893

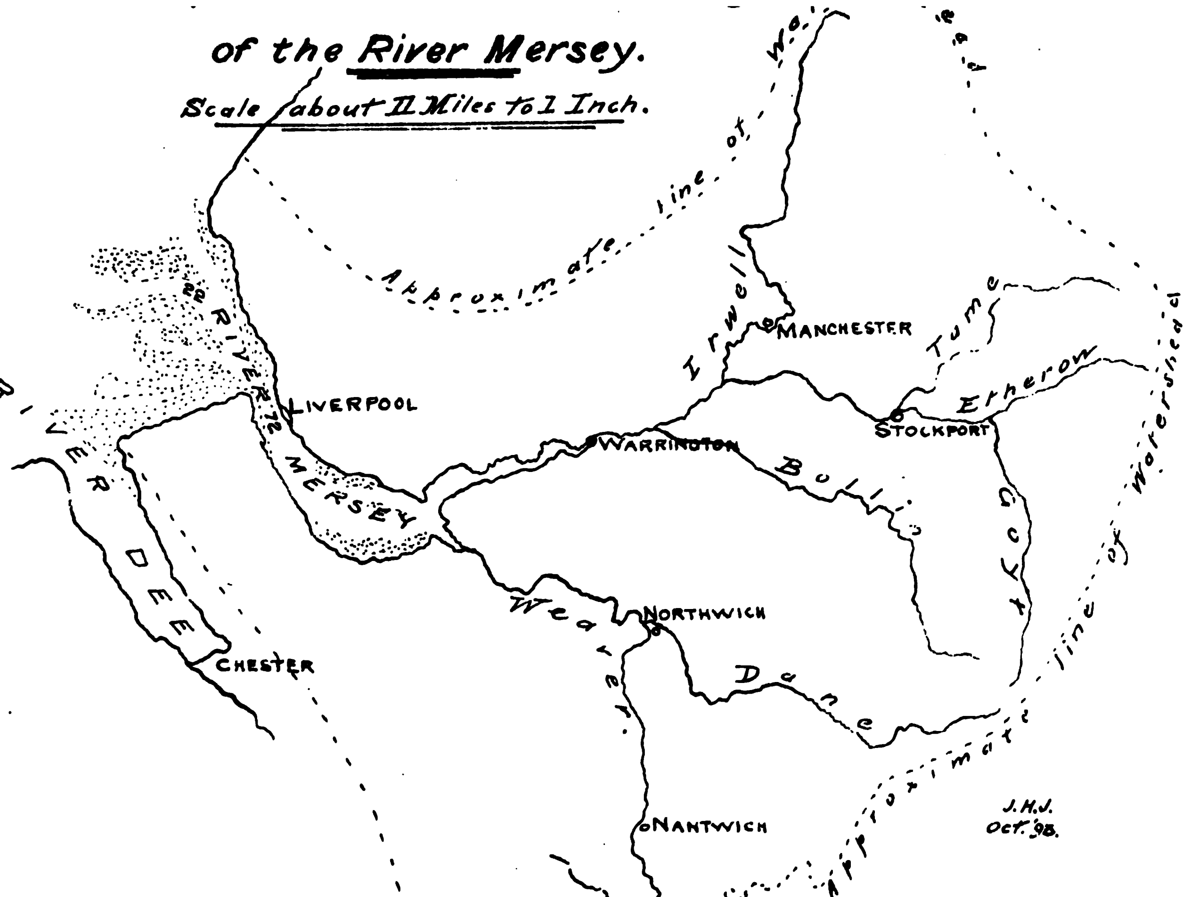
afford very fertile soils. The cretaceous or chalk, and also the mountain limestone of the carboniferous formation, produce sheep grazing land of the best description. The old red sandstone is noted for its fertile soils both in the South of Scotland and in England, where, on the cornstones of Herefordshire, the best beef-making cattle in the world are reared and fatted. The lias furnishes the best soil for dairying purposes in Gloucestershire, Somerset, Warwick and Leicester, whilst those of Cheshire, Worcestershire and Salop are derived from the trias. The silurian formation furnishes good hill pastures, and on the lower grounds excellent friable soils, but the older Cambrian rocks of Wales, &c., are the least cultivated, and consequently most thinly populated, parts of the kingdom.

The produce of a country would not, however, be of great value were it not for the facilities which exist for its transport from place to place, for the inhabitants of one district could not live on mineral products, neither could those of our hills entirely on mutton. Nature has, however, provided us with great commercial highways in the form of rivers. It seems scarcely necessary to point out to this Association the important connection between rocks and rivers, as so very much has been said on the subject from time to time in this room. It will be sufficient to state that the present form of every river is due to the conformation of the land and to the character of the rocks over which it flows. Their economic importance has therefore been determined for us by their geological surroundings; their depth or shallowness, their straightness or tortuosity, their rapidity or sluggishness, and the quantity of water they contain, are all due to those causes with which geology is concerned, and which have rendered many of them suitable as producers of power for use in connection with our industries, and as bearers of the resulting commercial products towards the sea.

The district which I wish to call special attention to as

that from which the greater part of the commerce of Liverpool arises is comprised within the basins of the rivers Mersey and Weaver, together extending to about 1300 square miles, and including the greater part of the Lancashire coalfield, the whole of the Cheshire salt district, and most of the chief manufacturing towns of Lancashire and Cheshire. This area embraces a population of considerably over 3,000,000 persons, or about one-twelfth of the whole United Kingdom, though the area occupied is only 1/42nd of the total of Great Britain and Ireland, thus showing its density to be very much above the average. The district rests mainly upon two important geological formations—the carboniferons and the triassic; but there is also a small strip of permian running through the towns of Manchester and Stockport. These formations are almost entirely covered by boulder clay. The carboniferous rocks extend over about 500 square miles, and the coal measures of this series produced in 1891 22,722,618 tons of coal, being about one-eighth of the total output of the kingdom. From the same formation are also obtained ironstone and fireclay, also building stone from the coal measures and millstone grit divisions.

The triassic formation occupies the remainder of the area, chiefly situated in Cheshire, and contains by far the largest deposit of salt known to exist in this country. Although there has recently been some falling off in the quantity got, owing chiefly to the discoveries made in foreign countries previously supplied by Cheshire, still the produce of 1891 amounted to 2,000,000 tons, of which about one-third was exported, the remainder being used at home for domestic and manufacturing purposes. The trias also affords a variety of good building stone, which has been largely used in the neighbouring towns in many important buildings; it also provides abundance of excellent water, and forms the chief source of supply for domestic purposes to most of the numerous towns situated upon it. A very large agricultural area in Cheshire is


of the River Mersey.
Scale about II Miles to 1 Inch.
Approximate line of Watershed
Approximate line of Watershed
Irwell
MANCHESTER
Tame
Etherow
STOCKPORT
Goyt
Bollin
LIVERPOOL
WARRINGTON
RIVER
MERSEY
22
72
RIVER DEE
CHESTER
Weaver.
NORTHWICH
Dane
NANTWICH
J.H.J.
Oct. 98.

included in this district, nearly the whole of which is upon the red marl of the keuper division of the trias, and th· soil is one of the best to be found in the kingdom for pastures. It has given to Cheshire a world-wide reputation for dairy produce. The demand for food by the great masses of people to be found in proximity to this district has stimulated the farmers to cultivate the land very highly, and they now supply large quantities of milk, potatoes, and a variety of produce of almost every description to the adjacent markets.

Turning to manufactures—the chief of which are spinning and weaving—although these industries took root in the district many centuries ago, when the whole of the work was done by hand, they owe their spread since the introduction of machinery to the extent and suitability of the head waters of the Mersey for the driving power required and for bleaching and other purposes, and to the river itself as a navigable one for the outlet of their products and as a feeder of the various artificial waterways which have been constructed for the same purpose. We find, therefore, that all the principal manufacturing towns of the district are upon, or near to, watercourses; and Manchester, whose present supply of water is taken from the Etherow (one of the tributaries of the Mersey), is under obligation to supply the factories on its banks with 13,600,000 gallons per day.

There can be little doubt, however, that the recent extension of mills, factories, engineering, chemical, glass, and other works of almost every description is due to the convenience of the coal supply. The number of cotton factories in the United Kingdom in 1890 was 2,538, and the persons employed in them 528,795. The imports of cotton for 1891 were 1,994 million lbs., valued at £46,000,000, and of this 1,812 million lbs. were retained for home manufactures. The whole exports of cotton goods for the same year were valued at £71,250,000, or nearly one-fourth of the whole exports of

the United Kingdom. When we consider what a large quantity of goods of this class is used at home, too, we cannot fail to realise the enormous importance of this industry to the trade of the kingdom.

Over 80% of the cotton industry is situated in the comparatively small area now under consideration. It is an extremely difficult matter to gauge the *wealth* of any one locality, but it was in 1882 stated in evidence before Parliament in connection with the Ship Canal Bill that the capital invested in the the *cotton industries alone* of the Manchester district was £100,000,000 sterling.

The geology of the locality seems, therefore, to have played the chief part in fixing these industries in the district in which they arose, and in contributing to their maintenance there and to their enormous and rapid extension.

So far, however, we have only dealt with the mines, manufactures and agriculture, but another feature still remains for consideration—namely, the facility for transport of the enormous quantity of goods arising in the district. Had this been wanting the riches which have been referred to would in all probability have remained hidden to this day, and the trade of this busy locality would have been unknown. The natural outlet for all this commerce is the river which passes through the centre of the district and has its termination in the magnificent harbour at its mouth. This harbour stands in the position of a connecting link between the manufacturing interests centred in Manchester and the mercantile interests which are the backbone of Liverpool. It would be difficult to say which is most dependent upon the other. Manchester cannot altogether do without Liverpool, and although she is making some attempt to pass the door of our docks she cannot ignore *the port*. On the other hand, Liverpool, if deprived of the trade of Manchester, would—well, perhaps fall to a third or fourth place amongst the seaports

of the kingdom. It is to this harbour that Liverpool owes her rise and prosperity. She has no manufactures of any account, and no mineral resources; and her wealth arises in great part from the handling and distribution of the raw material required for the various industries mentioned and of the resulting finished article, as well as an enormous quantity of other goods of every description arriving from and in course of transit to not only every corner of our own country but all parts of the world.

The value of the imports and exports of Liverpool in 1891 was £210,000,000, or about one-third of the whole for the kingdom.

The harbour of Liverpool, although perhaps somewhat difficult of access, is eminently fitted by Nature for the accommodation of a large quantity of shipping. At high water of a 21ft. tide it has an area of 44 square miles, it is well sheltered by the high grounds of Wirral from the most commonly prevailing winds, and affords anchorage for vessels of all sizes. But rivers, ports and harbours will not remain in the condition in which we may happen to find them without conservation any more than corn will grow without cultivation, or the minerals fashion themselves into those articles which we require without our labour. Natural forces are ever at work, and by them rivers may be improved for the purposes of navigation, or the reverse may take place. The question has often been asked—"Is the Mersey silting up?" and it is one which has no doubt caused a large amount of anxiety to Liverpool business men from time to time, but it seems only reasonable to conclude that the probabilities of such a catastrophe occurring have received the fullest consideration from those by whom it would be most severely felt. Judging from the large amount of capital which has recently been expended upon new docks and warehouses, and facilities for the landing of cattle, &c.—all of such a substantial

character that they seem destined to last for ever—it would appear that the authorities have concluded that there is no immediate cause for anxiety on this point. Everything that art can suggest is being done to assist Nature; the entrance channels are being dredged and the bar of the main channel cut away in order to allow of the passage of vessels of the largest type to the harbour at almost any state of the tide. These channels are also well lighted and buoyed, and a splendid pilotage service exists. The watchfulness and foresight which has characterised that body entrusted with the care of the port—the Mersey Docks and Harbour Board—has done much to improve the river and its approaches, and has thus encouraged trade and not only enabled Liverpool to hold her own against the world, but has, even in these days of the warfare of competition, contributed to her constant advancement.

It seems to have been in connection with Ireland that the Port of Liverpool was first recognised, for in the year 1172 it was selected as a suitable spot for the embarkation of troops. In 1430, it is recorded that Ireland exported to Liverpool fish, wool, hides, skins, and linen *cloth*. These exports have been continued to the present day, though the hides, skins and wool now come over chiefly in the form of the living animal, of which about 500,000 were landed last year. In 1641 they sent linen *yarn*, to be woven in Manchester by the weavers who had settled there from the Continent, and who were at that time carrying on a woollen manufacture, and *the cloth* was sent back to Ireland. We see from this that Liverpool was concerned in the import and export of Manchester goods two and a-half centuries ago. A record of 1542 informs us that small custom was paid here, but that does not seem to have had the effect of attracting trade any more than the "high" rates of the present day (which the Manchester Ship Canal supporters so much complained of) have of driving it away; for, twenty years later—viz., in 1565—the shipping of

Liverpool consisted of only 10 barques and 2 boats, of a total tonnage of 223 tons. In 1752 2,496 tons entered the port, since which time steady progress has been made; and from the accounts of the Mersey Docks and Harbour Board of last year we learn that the inward tonnage was 8,898,364 tons, and that 46,978 vessels entered and left the port, being an average of 129 per day.

Much might be said about the physical aspects of the river and estuary, which would be highly interesting to us as a geological body; but, as has been already mentioned, the subject of rivers generally has often been brought before you, and the Mersey has received particular attention from very able hands. I do not, therefore, purpose touching upon this aspect of the subject further, but hope that from what has been said it has been made clear that the physical features and geology of a country have a most intimate connection with commerce; that they have exercised, and still do exercise, a very important influence on the industries of our own country; that to the same features is due the suitability of our river and harbour for shipping, and as the natural outlet for the products of these industries. The guarding of both industries and the port is the duty and privilege of our own city, and the faithful carrying out of these has made her the important and prosperous one she is to-day and placed her foremost amongst the mercantile cities of the world.

FIELD MEETING.—Doulton's Delph, St. Helens, Saturday, 5th August, 1893, conducted by the Vice-President, Mr. T. R. Connell. In addition to many points of great geological interest studied in the Delph, some choice fossil ferns were exhumed and carried away.

FIELD MEETING.—Wrekin, Monday, 7th August, 1893, conducted by Mr. C. E. Miles. Ercul Hill, Laurence Hill, Wrekin Hill and Primrose Hill were visited in succession, and the geological features being very ably described by the conductor of the party, a fairly good idea of this, one of the oldest of British Volcanoes, was obtained.

ORDINARY MEETING,

Held in the Free Library, William Brown Street, on Monday, 4th September, 1893, the President, Mr. D. Clague, F.G.S., in the Chair.

ELECTION.—Mr. A. G. Jenks was elected a member.

NOMINATIONS.—Miss M. Stewart, L.L.A., 72, Falkland Road, Egremont, and Mr. J. Rennie, 70, Allington Street, were nominated for membership.

ELECTION OF AUDITORS.—Dr. Cecil F. Webb and Mr. R. Williams were elected Auditors.

Mr. H. T. White read a short communication on Landscape Marble, illustrated by two interesting specimens.

The following Paper was read:

THE METAMORPHIC ORIGIN OF GRANITE.

By R. W. BOOTHMAN ROBERTS.

THE question of the origin of granite is one upon which there has been, and still is, considerable difference of opinion amongst geologists. It was at first universally believed that granite was always of igneous origin, in fact, that rock was generally selected as the type of the plutonic igneous rocks—but of late there has been manifested an increasing tendency to regard it as being, in many cases, a metamorphic rock. The facts and arguments upon which this conclusion is based may be grouped under seven heads:--intimate association with gneiss and other schists,—discordant contact with schistose

rocks,—included fragments of sedimentary rocks,—evidences of stratification,—internal evidence of the quartz of granite,—liquid inclusions,—the presence of minerals which would have had their optical or physical properties altered by heat.

With reference to the close association of granite with gneiss, and other metamorphic rocks, it is well known that there are many localities where a gradual passage may be traced from comparatively unaltered sedimentary strata, through mica schist and gneiss, to granite. This transition naturally suggests the conclusion that the granite is only the ultimate result of the metamorphism which produced the schists. The probability of this is readily grasped when it is remembered that there is no difference between granite and gneiss either in mineral or chemical composition, the only distinction being in the foliation of the latter. And this foliation is sometimes so indistinct that even experienced observers fail to distinguish the gneiss from the granite. In fact, it frequently happens that it is only when viewed in large masses that the foliation of gneiss can be recognised, hand specimens of it exactly resembling granite. Illustrating the gradual passage of gneiss into granite, there is a section in the Matterhorn in the Alps, where along with other greatly contorted beds, there occurs a thick stratum which is gneiss at the westernside of the mountain, and granite on the eastern. Ramsay also mentions the occurrence in Canada and in the Alps, of gneissic rocks regularly interbedded with less altered strata, the gneiss being so crystalline that in a hand specimen it is impossible to distinguish it from some granitic rocks, and even on a large scale the uneducated eye will constantly mistake the gneiss for granite. Professor Hayden, in the Report of the United States Geological Survey for 1872, describes the rocks of the Middle Park division of Colorado as a great system of ancient sedimentary strata, which have undergone the most perfect metamorphosis, the result of which over large areas has reached the last stage of metamorphism, viz.:—structureless granite. In Southern Colorado a considerable portion of

the granite is believed to be metamorphosed Silurian and Devonian strata. In the Quartzite Mountains in the same locality, a direct transition is apparent from sedimentary rocks into typical granite. Professor Clarence King in the Report of the Exploration of the 40th Parallel, expresses the opinion that the great masses of crystalline schists, and allied granites of that region were all formed out of pre-existing sediments. Sterry Hunt also assigns a similar origin for many of the Canadian granites. In Galway and Donegal in Ireland, the granites are with difficulty separable from the surrounding gneiss. The instances given will be sufficient to show that there is frequently a very close connection between gneiss and granite, and that if a metamorphic origin is assigned to the gneiss, the granite also must be allowed to be metamorphic. With regard to the manner in which granite may result from the alteration of sedimentary strata, the following explanation is given by Sir A. Ramsay :— "The heat in the interior of the globe in places sometimes apparently capriciously eats its way towards the surface by the hydro-thermal fusion or alteration of parts of the earth's crust, in a manner not immediately connected with the more superficial phenomena of volcanic action, and for this, among other reasons, it may happen that strata which are contorted have in places been brought within the direct and powerful influence of great internal heat. Under some circumstances we can easily understand how stratified rocks may have been so highly heated that they were actually softened, and most rocks being moist, (because water that falls upon the surface often percolates to unknown depths) chemical actions were set going resulting in a rearrangement of the substances which composed the sedimentary rocks." Supposing that sedimentary rocks, after being carried down by faulting or contortion to a sufficiently great depth were brought by hydro-thermal action into a viscous or semi-fluid condition, then a portion of this viscous mass might be injected into the overlying strata, and then we should have possibly a granite vein apparently eruptive but really of metamorphic origin. It is probable that many, if not all, of the so-called

eruptive granites, if they could be traced to a sufficient depth would be found to be really metamorphic in their origin.

The second argument to be considered is that which is derived from the discordant contact of granite with surrounding stratified or schistose rocks. This discordance is in many case of a most pronounced character, and can only be explained by supposing the granite to be metamorphic, and to have gradually as it were, eaten its way upwards. This structure is well illustrated in Ireland, especially in Leinster and in the Mourne Mountains. Professor Jukes called attention to a section in the former locality, in which there is a granite ridge surmounted by beds of mica schist, alternating horizontally with veins of granite, while on the flanks of the ridge the schists dip towards the main mass of granite, and terminate downwards against an irregular surface of the latter. A section of Stievesmaddy Hill, in the Mourne Mountains, is just as conclusive. In this case, contorted Silurian schists are found partially covering and dipping downwards into the granite. These schists are cut through by dykes of basalt, but both terminate abruptly against the granite. MacCulloch gives a section of very similar character, occurring in the Western Highlands. Ramsay also records analogous phenomena in the older rocks of Anglesea. He states that granite and its allies frequently occupy the spaces which ought to be filled with gneiss or other rocks, were it not that they have been entirely fused and changed into granite. In Ireland, the officers of the Geological Survey have distinguished two kinds of granite, one metamorphic and the other igneous. The metamorphic variety appears to be characterized by the presence of the larger proportion of plagioclase felspar.

Of course, sections such as those in Ireland are not very common, on account of the amount of denudation which is necessitated before the granite can be exposed at the surface. A depth of thousands of feet would have to be reached before the temperature would be sufficient, even with the presence of water, to effect the conversion of sedimentary strata into

granite. But it must not be supposed that the heat required to produce this effect would be as great as that needed for the simple igneous fusion of the rocks. Sterry Hunt states "that the presence of from 5% to 10% of water may suffice, at a temperature approaching redness, to give to a granite mass a liquidity partaking at once of the character of an aqueous and an igneous fusion." Of course the temperature required to produce red heat in a rock is very far short of that needed to effect igneous fusion.

If, as we suppose, granite has been derived from the alteration of sedimentary rocks, we should naturally look for some traces of the original rocks. These we find in some of the inclusions which occur so frequently in granite. But we must carefully distinguish between the rock fragments which have been caught up by intrusive granite and those fragments which are the true representatives of the original rock from which the granite has been derived. In intrusive granite veins these inclusions are usually found to occur most plentifully near the junction of the granite with the surrounding strata, whereas in metamorphic granites the reverse is the case. The inclusions are generally considerably metamorphosed, and in large included masses a gradual passage may sometimes be noticed from the granite to the comparatively unaltered rock, the intensity of the metamorphism diminishing from the outside to the centre of the mass. Dr. J. Geikie mentions the occurrence in the grey granite of the southern uplands of Scotland of nests of altered rock, consisting of dark fine-grained or semi-crystalline rock, often showing traces of lamination. Sometimes there is a sharp line between the granite and the included fragments; at other times the passage is gradual. They may be remnants of thin bands or beds of shale interleaved in the original strata, from which the granite has been formed by metamorphic action; for if they were fragments broken off they should be most abundant near the junction, but they are not. Included fragments of rock are common in the granite of Central

France. In the granite of the Forez Mountains blocks of gneiss are frequently found, although this latter rock does not exist in the chain itself. Similar fragments of gneiss are also found in the Vosges Mountains and in the Pyrenees. In America there are numerous illustrations of this phenomenon. In Colorado the granite encloses masses of schistose rock several hundred feet in length, which shade off gradually into the surrounding rock. They are stated to be "not broken off and enclosed portions of schists, but remnants of bedding not obliterated by metamorphism." That portions of the sedimentary strata should successfully resist the tendency to be converted into granite is quite comprehensible when we remember that the chemical composition of a deposit may vary considerably in different places. An increase in the silica percentage and a corresponding decrease in the percentage of alkalies would probably enable a bed to successfully resist fusion.

Appearances suggestive of stratification are by no means uncommon in granite. In the granite of Mont Blanc distinct stratification has been observed, and in England the Mount Sorrel granite is believed to show evidences of bedding. These appearances are quite independent of the jointing sometimes noticed in granites.

With reference to the quartz of granite, the fact that this mineral has been the last to crystallise out may be taken as a proof that granite has not resulted from simple igneous fusion, for had such been the case the quartz, being more infusible than either felspar or mica, would have solidified first. The presence of large numbers of liquid inclusions in the quartz also points to the same conclusion. The minute cavities in which these inclusions are contained are so numerous that they have been calculated to make up sometimes as much as 5% of the volume of the rock. The liquid is usually water, and the presence of this would render the complete crystalline rearrangement of a sedimentary rock possible at a temperature which would be low compared to that necessary

for igneous fusion. With respect to the quartz of granite it has also been remarked that its specific gravity is 2·6, whereas that of silica, which has undergone igneous fusion, is only 2·2.

The last argument in favour of the metamorphic origin of granite is that which is derived from the occurrence of minerals in granite which would have had their physical properties affected by heat. Pyrorthite, orthite, and other minerals lose their phosphorescence when heated, and brookite and some felspars have their optical properties changed by heat.

It is not endeavoured to prove that all granites are of metamorphic origin—that is rather more than the evidence at present warrants us in assuming. Some may be of igneous origin—as, for instance, the Shap granite, the quartz of which, according to Messrs. Harker and Marr, has been the first mineral to crystallise. But we are justified in believing that granite may result from hydrothermal metamorphism, and that many granites have so originated. Rutley thinks that, considering the deep-seated origin of the metamorphic granites, and the fact that the metamorphosed rocks have been completely reduced, if the term metamorphic granite is used then all distinction between igneous and metamorphic rocks ceases. But this objection is scarcely a very serious one. Astronomy teaches that the earth was at one time in a molten condition, and that probably the interior of the earth is still in a state of fluidity, or, perhaps, potential liquidity. Now, it is to the rock or rocks which result from the solidification of this original magma that the term igneous should be applied. There would then be no confusion in the use of the terms igneous and metamorphic. Of course this magma, when slowly cooled at great depths below the earth's surface, might result in the formation of granite which would then be a true igneous rock, but that consideration need not interfere with the application of the term metamorphic to such granites as have obviously resulted from the hydro-thermal fusion of sedimentary strata.

ANNUAL MEETING,

Held at the Free Library, William Brown Street, Monday, 2nd October, 1893, the President, Mr. D. Clague, F.G.S., in the Chair.

Elections.—Miss Mary Stewart, LL.A., and Mr. J. Rennie were elected to membership.

The Annual Report of the Council, including the Reports of Committees, were read and adopted.

The following

OFFICERS AND COUNCIL

For Session 1893-94

were then elected :—

President :

Mr. D. Clague, F.G.S.

Vice-President :

Mr. T. R. Connell.

Secretary :

Mr. W. Scott-Walker.

Treasurer :

Mr. J. Paterson.

Council :

Mr. C. F. Webb, D.D.S.
Mr. A. R. Pritchard.
Mr. W. H. Miles.
Mr. J. H. Jones.
Mr. C. E. Miles.

The remainder of the evening was devoted to free conversation, members narrating their observations on the geological lessons learned during the holiday season. Numerous mineral, petrological, and fossil specimens were exhibited.

Annual Report, 1892-3.

In accordance with the usual custom, the Council place before you a statement of the position of the Society, and also report on the work done during the past year.

At the commencement of the year the number on the roll was 76—that is, 6 honorary and 70 ordinary members. Since then 1 honorary and 13 ordinary members have been elected, 4 have handed in their resignations, 4 have been struck off under Rule 2, and 3 more have unfortunately been removed by death, leaving 7 honorary and 72 ordinary members—total 79; being an increase of 3 on the previous year.

The following papers were read at the ordinary meetings, which were held on the first Monday in the month, general holidays excepted:—

"The Geology of Wirral," by Mr. Jeffs.
"Eozoon," by Dr. Webb.
"Two Days on the Gault and Greensand," by Mr. W. L. Atkinson.
"The Mountain Limestone of North Wales," by Mr. A. R. Pritchard.
"The Flora of the Coal Measures," Mr. D. Clague.
"The Influence of Local Geology on the Commerce of Liverpool," by Mr. J. H. Jones.
"The Metamorphic Origin of Granite," by Mr. R. W. B. Roberts.

The Library has, through the efforts of the Chairman of the Committee, been carefully catalogued, and it now contains a very useful selection of scientific works ready for the use of members. Its value has been greatly increased during the past year by liberal donations from the British Museum and

the United States Geological Survey. Further particulars will be found in the Library Committee's Report.

The Publishing Committee, after printing three numbers of the Journal at the commencement of the year, decided that it would be better not to increase the liabilities of the Society in this direction. The advantage of this retrenchment can be seen in the Treasurer's Report, which shows a small balance to the credit of the Association.

The subscriptions for the new session are now due, and the work of the Committee would be considerably lightened if members would pay them at an early date.

The Council in arranging the programme of excursions for the summer of 1893 were influenced by past experience. Previously, as a rule, a large number of excursions were arranged and only a small number of members found it convenient to be present. It was thought probable that if fewer excursions were planned a larger attendance would be obtained. This idea was acted upon, and the desired result was to some extent realised.

On Whit Monday a visit was paid to the Upper Mountain Limestone at Newmarket, which is exposed on the sides of the hill and quarries of the district. A good number of fossil remains were obtained from the Upper Grey division, which is fully described by Mr. Morton in "The Geology of Liverpool and District."

Two excursions were paid to the coal measures in the neighbourhood of St. Helens, and some very fine specimens of carboniferous flora were obtained and exhibited at one of the ordinary meetings.

The last excursion was made on August Bank Holiday, when a party went to Wellington to examine the Wrekin district, under the guidance of Mr. C. E. Miles, whose knowledge of the geology of that neighbourhood enabled the members to obtain a good idea of the geological structure of the Wrekin Hills.

Library Committee Report.

The Library Committee have to report as follows :—

In the course of the year the Library has had considerable accessions in donations and exchanges, lists of which are appended.

The best thanks of the Association are due to the donors.

The number of members using the Library for reference purposes is 37 ; books taken out, 41.

The bound books available for reference number 218.

Reference was made in the Report of last year as to the incompleteness of many volumes of Transactions of other societies. This during the year has been partly remedied, and it is hoped in the course of the coming year that all the sets will be made complete.

For the Committee,

THOS. R. CONNELL, *Secy.*

LIVERPOOL GEOLOGICAL ASSOCIATION, in Account with the Treasurer.

FOR THE YEAR ENDING SEPTEMBER, 1893.

Dr. DISBURSEMENTS.	£	s.	d.
To Printing and Stationery	5	0	0
,, Postage and Incidentals	3	1	6
,, Rent of Room to May, 1893	2	5	0
,, Gratuity to Attendant	0	10	0
,, Balance in hands of Treasurer	6	2	3
	£16	18	9

RECEIPTS. *Cr.*	£	s.	d.
By Balance from last year	0	3	1
,, Subscriptions—			
2 for year 1890-91			
9 ,, 1891-92			
39 ,, 1892-93			
8 ,, 1893-94			
3 ,, 1895-96-97			
—			
61 Subscriptions at 5s.	15	5	0
,, Receipts from Authors for Printing	1	10	0
,, Sale of Pamphlets	0	0	8
	£16	18	9
By Balance	£6	2	3

1st Dec., 1893.—Audited and found correct,

(Signed) RICHARD WILLIAMS.
CECIL F. WEBB.

(Signed) C. E. MILES (for W. H. Miles, dec.),
HON. TREASURER.

LIST OF DONATIONS AND EXCHANGES, 1892-3.

DONATIONS.

T. Mellard Reade, F.G.S.—On "The rounding of Sandstone Grains in the Trias."

Do. —On "The Trias of Cannock Chase."

Do. —On "Eskdale Drift and its bearing on Glacial Geology."

Do. —On "Glacial Geology."

Do. —On "Glacial Geology, Old and New."

Do. —On "Geological Time."

O. W. Jeffs —"In Memoriam — A. Norman Tate."

Do. —"CommercialAspect of Geology."

Do. —"Geology of Wirral," &c.

T. R. Connell —3 Photographs, Doulton's Delph, St. Helens; 1 Photograph, BasingworkAbbey, Holywell.

EXCHANGES.

Birmingham Natural History and Microscopical Society, 1892.

Burnley Literary and Philosophical Society, vol. 8.

Cardiff Naturalists Society, vol. 24, part 2.

Cornwall Mining Association and Institution, part 3, vol. 3; part 1, vol. 4.

1892-93.

Copies of the *Journal* of the Association, Vol. XIII., 1892-3, have been sent to the following institutions and societies, and exchanges received from those marked with a *.

GREAT BRITAIN AND IRELAND.

*Birmingham Natural History and Microscopical Society.
Bristol Naturalists' Society.
*Burnley Literary and Philosophical Society.
*Cardiff Naturalists' Society.
Chester Society of Natural Science.
Cornwall Royal Geological Society, Penzance.
* ,, Mining Association and Institute.
Cotteswold Naturalists' Field Club, Cheltenham.
Cumberland and Westmoreland Association for the Advancement of Literature and Science.
Falmouth Naturalists' Society.
*Isle of Man Natural History and Antiquarian Society.
*Leeds Geological Society.
* ,, Philosophical and Literary Society.
Liverpool Astronomical Society.
,, Engineering Society.
* ,, Geological Society.
,, Literary and Philosophical Society.
* ,, Microscopical Society.
* ,, Naturalists' Field Club.
* ,, Science Students' Association.
,, University College.
*British Museum, N.H.D., Cromwell Road, London, S.W.
London Amateur Scientific Society.
City of London College Scientific Society.

London Geological Society.
* ,, Geologists' Association.
*Manchester Geological Society.
* ,, Microscopical Society.
,, Scientific Students' Association.
**Midland Naturalist*, Birmingham.
Nottingham Naturalists' Society.
Norwich Geological Society.
Rochdale Literary and Scientific Society.
Yorkshire Geological and Polytechnic Society, Halifax.
* ,, Philosophical Society, York.
Edinburgh Geological Society.
*Glasgow Geological Society.
Belfast Naturalists' Field Club.
Free Libraries—Barrow-in-Furness, Chester, Birmingham, *Birkenhead, *Bootle, *Liverpool, St. Helens, Warrington, Nottingham, Southport.

AUSTRALIA.

*Australian Museum (the Trustees of the), Sydney, N.S.W.
*Australasia Geological Society, of Melbourne, Victoria.
*Department of Mines, ,, ,,
School of Mines, Stawell.

NORTH AMERICA.

Geological and Natural History Survey of Canada, Ottawa.
Nova Scotian Institute of Natural Science, Halifax.
*Geological Survey, Washington, D.C., U.S.A.
*Smithsonian Institution, ,, ,,
*Elisha Mitchell Scientific Society, Chapel Hill, N.C., U.S.A.
*Public Museum, Milwaukee, Wisconsin, U.S.A.
Wagner Free Institute of Science, Philadelphia.
*Academy of Science, Art and Letters, Madison, Wisconsin U.S.A.
State Mining Bureau, Sacramento, Cal., U.S.A.

Isle of Man Natural History and Antiquarian Society, vol. 1, part 11.
Leeds Geological Society, part 7.
Leeds Literary and Philosophical Society, 1893.
Liverpool Geological Society, vol. 5, parts 1 and 2; vol. 6, part 4.
Liverpool Microscopical Society, 1893.
Liverpool Naturalists' Field Club, 1892.
Liverpool Science Students' Association, 1890-1, and 1891-2.
British Museum, Natural History Department.
London Geologists' Association, from part 8, vol. 12, to part 3, vol. 13.
Manchester Geological Society, vol. 22, parts 1 to 11.
Manchester Microscopical Society, 1890, 1891, 1892.
Midland Naturalist, parts 173, 178 to 187.
Yorkshire Philosophical Society, 1892.
Glasgow Geological Society, vol. 9, part 11.
LIBRARIES—Liverpool, Birkenhead, Bootle.

Australian Museum (The Trustees of), Sydney, N.S.W.
Australasia Geological Society, Melbourne.
Victoria Department of Mines, „

Geological Survey U.S.A., Washington, D.C.
Smithsonian Museum, „
Elisha Mitchell Scientific Society, Chapell Hill, N. Carolina.
Wisconsin Academy of Science, Art and Letters, Madison, Wis.
Public Library, Milwaukee, Wis.